2015

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Climate Risk Management 7 (2015) 20–30

Contents lists available at ScienceDirect

Climate Risk Management

journal homepage: www.elsevier.com/locate/crm

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ARTICLE INFO

Article history:
Available online 28 February 2015

Keywords:
Decision calendar
Maps
Agriculture
Climate tools

ABSTRACT

The usefulness of climate information for agricultural risk management hinges on its availability and relevance to the producer when climate-sensitive decisions are being made. Climate information providers are challenged with the task of balancing forecast availability and lead time with acceptable forecast skill, which requires an improved understanding of the timing of agricultural decision making. Achieving a useful balance may also require an expansion of inquiry to include use of non-forecast climate information (i.e. historical climate information) in agricultural decision making. Decision calendars have proven valuable for identifying opportunities for using different types of climate information. The extent to which decision-making time periods are localized versus generalized across major commodity-producing regions is yet unknown, though, which has limited their use in climate product development. Based on a 2012 survey of more than 4770 agricultural producers across the U.S. Corn Belt region, we found variation in the timing of decision-making points in the crop year based on geographic variation as well as crop management differences. Many key decisions in the cropping year take place during the preceding fall and winter, months before planting, raising questions about types of climate information that might be best inserted into risk management decisions at that time. We found that historical climate information and long term climate outlooks are less influential in agricultural risk management than current weather, short term forecasts, or monthly climate projections, even though they may, in fact, be more useful to certain types of decision making.

Introduction

Agricultural production in the U.S. Corn Belt depends upon favorable weather, and climate variability affects agricultural decisions and outcomes at many points throughout the year (Motha and Baier, 2005; Andresen et al., 2012). Producers'

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http://dx.doi.org/10.1016/j.crm.2015.01.004
2212-0963/

forecast "horizons" of interest (e.g., drought next month, early frost next fall, El Niño next growing season) change throughout the year and may focus on different weather variables. Climate outlooks and historical climate information should therefore be valuable to agricultural producers for decision making and risk management (Mjelde, 1986; Keating et al., 1993; Hammer et al., 1996; Cabrera et al., 2007; Selvaraju, 2012). Scholars have suggested that producers' successful adaptation to future climate variability and change will depend upon increasing their use of climate information (Meinke and Stone, 2005). In fact, a key message of the agriculture chapter of the recent U.S. National Climate Assessment (Melillo et al., 2014) states that "*. . .increased innovation will be needed to ensure the rate of adaptation of agriculture and the associated socioeconomic system can keep pace with future climate change*."

Yet, interestingly, agricultural decision makers have not widely adopted the use of climate information in their risk management decisions (Ash et al., 2007; Livezey and Timofeyeva, 2008; Lemos et al., 2012), which leads researchers to question what can be done to improve the perceived value and use of climate information in agricultural risk management. While a large body of research focuses on improving forecast skill (Hoskins, 2013; Magnusson and Källén, 2013), other characteristics of the forecast such as lead time or the context in which decisions are made may be just as important in increasing its use (Mjelde, 1986; Easterling and Mjelde, 1987; Hammer, 2000; Letson et al., 2005; Meinke and Stone, 2005; Cabrera et al., 2007; Asseng et al., 2012). Agricultural producers make decisions on multiple time-scales, ranging from operational decisions (which will be carried out in the next few days) to tactical decisions (carried out in future weeks or months) and strategic decisions (carried out in future seasons or years or beyond) (Hollinger, 1991). Opportunities for inserting climate information into tactical and strategic management depend on the availability of relevant information when those decisions are being made (Easterling and Mjelde, 1987; Changnon et al., 1988; Sonka et al., 1988; Hansen, 2002; Mase and Prokopy, 2014). For this reason, lead time may one of the most important aspects of climate forecast usefulness (Easterling and Mjelde, 1987; Sonka et al., 1988). The challenges in balancing acceptable lead time with an acceptable level of skill call for a better understanding of when specific types of climate information are needed by agricultural decision makers.

Decision calendars help identify opportunities for inserting climate information into a decision process as well as points where other considerations might overrule use of the climate information (Changnon et al., 1988; Pulwarty and Melis, 2001; Wiener, 2004; Corringham et al., 2008; Takle et al., 2014). A decision calendar is developed around the assumption that the timing of decisions and management practices is "cyclical and recurrent" (Aubry et al., 1998; Dounias et al., 2002). Developers of decision calendars are challenged, though, by a potentially infinite number of modifications required to address spatial variability in agricultural decision making. Variability in climate, soils, and agricultural production systems across a region may result in deviations in decision-making times. For example, Takle et al. (2014) developed a prototype of a climate-based decision calendar for corn production for the central U.S. Corn Belt region (Iowa, northern Illinois, and northern Indiana). Whether the calendar represents decision timing across the broader U.S. Corn Belt is examined here.

The Takle et al. (2014) calendar presumes decisions must consider both natural variability within climate normals and departures from past norms. Therefore, both historical climate information and a forecast of future climate are needed for the decision to be optimum. The use of historical climate information appears to be less examined in the literature than the use of climate forecasts. Changnon et al. (1988) and Sonka et al. (1988) found agribusiness professionals (e.g., seed corn company decision makers) incorporated historical climate information into their decision-making more often than climate outlooks, yet placed a higher value on predictions than on historical information. A better understanding is needed regarding the ways farm decision makers are influenced by, and could potentially use, historical climate information together with climate forecast and climate change information.

In this paper, we explore U.S. Corn Belt farmers' use of climate information and how that information fits into the timing of tactical decisions at the heart of on-farm management of climate risk, including input purchases, seeding rate, tillage, insurance, cover crops, and propane purchase for grain drying. We use our findings to describe implications for developing usable climate information tailored to agricultural risk management.

Materials/methods

The U.S. Corn Belt is a commodity-producing region that spans an area of significant climatic, geological, and vegetative gradients. The Modified Köppen classifications for the area range from semi-arid steppe (Bsk) across far western sections to microthermal humid continental mild summer (Dfb) across northern sections to microthermal humid continental hot summer (Dfa) elsewhere. Average annual temperature varies by about 8 °C across the region, from just under 6 °C in central Minnesota to more than 13 °C in southern Illinois and Indiana. Base 10 °C seasonal growing degree day totals, a temperature-derived index of time spent above the 10 °C-threshold that is used to quantify thermal crop requirements, range from around 1400 in central Minnesota to more than 2250 in southern Illinois. Average annual precipitation generally increases from west to east across the region, ranging from about 400 mm in western Nebraska to more than 1200 mm in southern Indiana. Precipitation in the Corn Belt occurs in all months and seasons, with some seasonality that varies from east to west across the region. Soils across the Corn Belt also vary widely, including loess-dominated soils across most western and central sections of the region, alluvial soils near major rivers, and coarse-textured soils elsewhere. Northeastern soils are highly heterogeneous resulting from repeated glaciations, while southeastern soils are relatively old, homogeneous, and highly weathered (Andresen et al., 2012).

Data were collected via a stratified random sample survey of agricultural producers, including farm operations with more than 80 acres of corn production and a minimum of US$100,000 of gross sales. The sample was stratified by 22 six-digit Hydrologic Unit Code (HUC) watersheds in 11 Corn Belt states including Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin, in order to address spatial variation in climate, hydrological, and ecological conditions (Fig. 1). The survey was mailed in February 2012 to 18,707 eligible agricultural producers. Completed surveys were received from 4778 producers for an effective response rate of 26%. Survey respondent age ranged from 22 to 98, with an average age of 55 (St. Dev. = 11). On average respondents owned 359 acres (min = 0; max = 13,760; St. Dev. = 504) and rented 561 acres (min = 0; max = 11,226; St. Dev. = 702). The survey was a collaborative effort between two USDA-funded projects, Useful to Usable (U2U) and Cropping Systems Coordinated Agricultural Project (CS-CAP). For complete methodology, see Arbuckle et al. (2013).

Respondents were asked to indicate the primary month in which they make decisions about crop rotations and field assignments, seed purchase, seeding rate, fertilizer and pesticide purchase, crop insurance, use of fall tillage, propane purchases, and use of cover crops. Respondents were also asked when they carry out activities related to corn production, such as applying fertilizer, tilling fields, and planting cover crops, data which we do not display in this paper but use to put decision-making dates in context. We were able to estimate, by watershed, the percentage of producers making decisions and carrying out farm work in any given month to within 8 percentage points. For display in this paper, we aggregated decision timing by meteorological season (December/January/February (DJF), March/April/May (MAM), June/June/August (JJA), and September/October/November (SON)). Data on decision timing by month will be available in a companion atlas available at http://agclimate4u.org.

Respondents were also asked whether they used weather-based decision-support resources related to these decisions, including growing degree day tools, drought monitors/outlooks, crop disease and insect forecasts, forage dry-down tools, and satellite data/indices of water or soil nitrogen status. Finally, they were asked how much their farming decisions were influenced by different types of weather and climate information, including historical information, information from the past 12 months, current weather, 1–7 day forecasts, 8–14 day outlooks, monthly/seasonal outlooks, and annual or longer term outlooks. Survey data were analyzed using STATA (Version 12) and displayed using ArcMAP 10.

Adding richness and meaning to this quantitative data, we also explored on-farm decision making in five focus groups with 48 corn producers in Indiana and Nebraska. Focus group participants were selected randomly from major corn

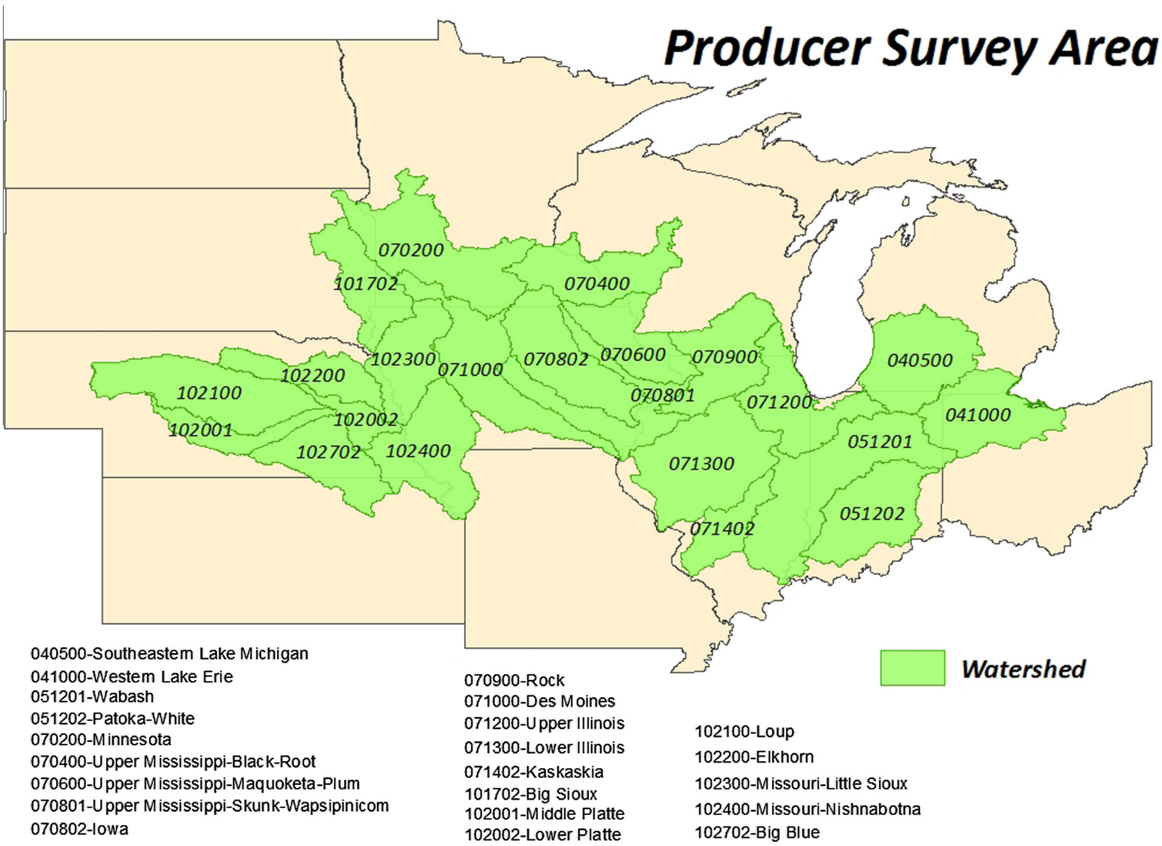

Fig. 1. U.S. Corn Belt watersheds included in survey. *Figure courtesy:* Loy et al. (2014).

production counties in the two states using Farm Service Agency mailing lists or in cooperation with county Extension Educators. The focus groups met one or two times between July 2012 and August 2013. Discussions were focused on producers' climate information needs, and included questions with regard to timing of fertilizer application, planting, seed purchases, and other decisions. The focus group discussions were audio and video recorded, and either transcribed for analysis or summarized in notes taken by project investigators. Passages taken from transcriptions of the focus groups are used in this paper to provide support for, examples of, and contradictions to our statistical findings.

Results

Geographic variation and timing of tactical decision making throughout the crop year

Use of fall tillage

The choice of whether or not to till fields in the fall (if tillage is used) is perhaps one of the first decisions agricultural producers make that affects the upcoming crop year. More than two-thirds of all respondents said they made decisions about using fall tillage just ahead of tillage time in mid-fall (primarily October) (Fig. 2). Most of the remaining one-third did not use

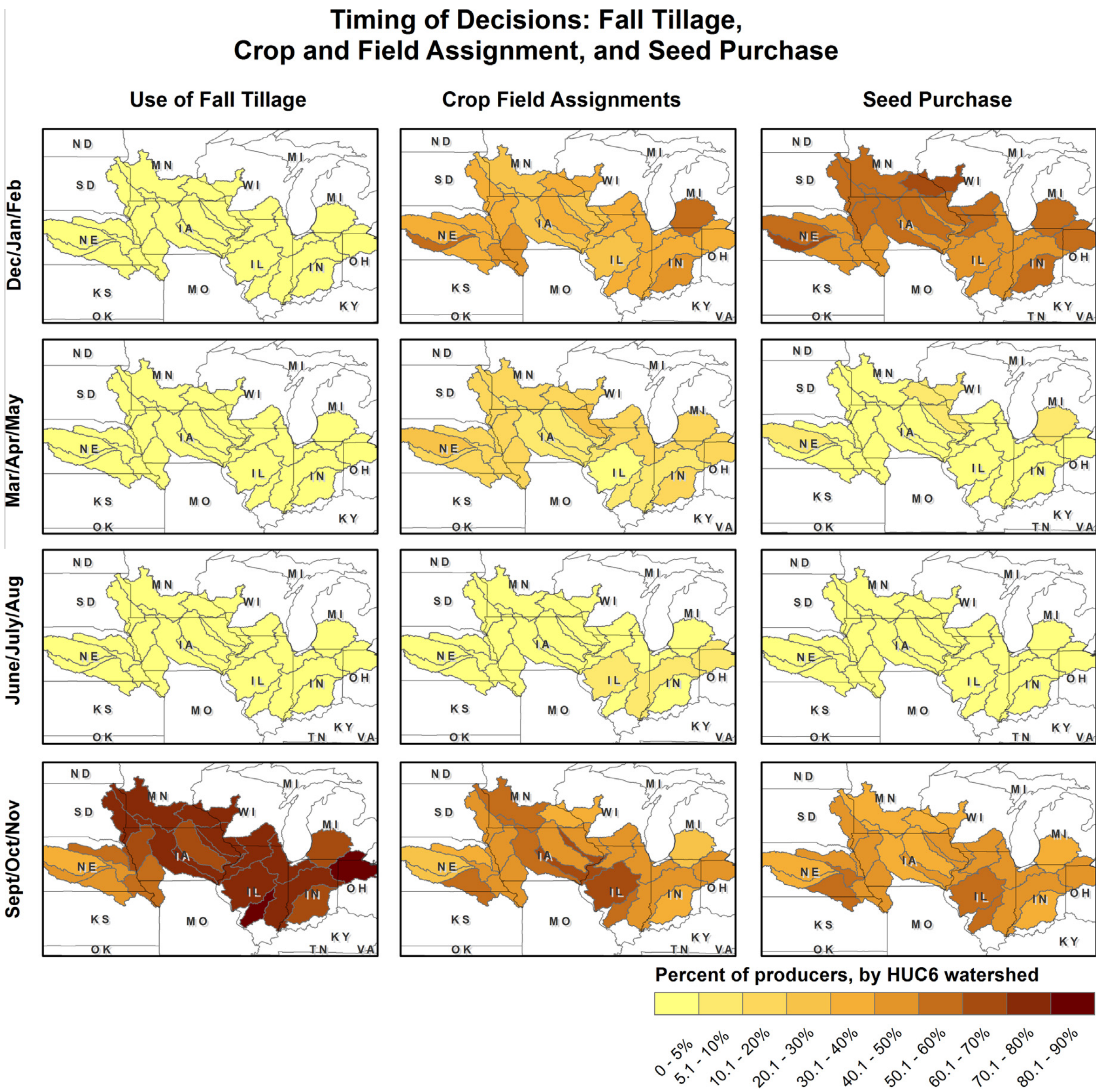

Fig. 2. Percent of producers, by watershed, making fall tillage, crop and field assignment, and seed purchase decisions in each season.

tillage at all. The decision to use fall tillage may be driven by the need to prepare fields for fall-planted cover crops, correct soil compaction issues caused by wet harvest conditions, or minimize the risk of planting delays in the spring due to wet weather.

Crop and field assignment and seed purchase

More than 80% of respondents overall said they made crop and field assignments and seed purchase decisions between mid-fall and the end of winter, although in northern watersheds up to 25% of producers reported making decisions about crop and field assignments through spring planting time (Fig. 2). Crop rotation and field assignment decisions may take into consideration not only what's been planted in the field in previous years, but also which crops are likely to be profitable, when fields will likely be ready for planting, and how prone fields are to climate risks such as drought. Seed purchase decisions concentrate on hybrid selection, with the consideration of season length as well as yield potential and disease and pest resistance. Focus group participants described the lag time between purchase decisions and actual planting as being driven by input companies offering discounts to lock in purchases as early as possible, and they have observed a trend towards earlier fall purchases that is likely to continue.

Fertilizer and pesticide purchase

About 75% of respondents reported making decisions about fertilizer purchases around the same time as seed purchases (mid-fall through winter), driven by marketing promotions that offer price discounts when purchases are bundled. Of the one-quarter of producers who reported making these decisions throughout the spring and summer, percentages ranged by watershed from 7% to 29% for spring decisions and from 1% to 16% for summer decisions (Fig. 3). Variation in fertilizer purchase decisions appeared to be related somewhat to farm management decisions about timing of anhydrous and dry fertilizer application, with fall application slightly increasing the likelihood of summer and fall purchase decisions and spring application slightly increasing the likelihood of winter and spring purchase decisions (Table 1).

Respondents reported making pesticide purchase decisions slightly after fertilizer purchase decisions, with 44% overall making the decision during winter months and 27% making the decision in the spring. Pesticide purchase decisions showed some spatial variation, with producers in the central Corn Belt more likely to make winter decisions, and those in parts of the western Corn Belt (and southern Michigan) more likely to make decisions into the spring or even early summer. Type and timing of pesticide application did not appear to be related to timing of decisions about pesticide purchases.

Seeding rate

Although major seed purchase decisions were made during fall and winter months, 45% of respondents reported making their seeding rate decisions in the spring, reflecting the fact that adjustments to seed orders may be made up to time of delivery of the seed at planting time. This decision may be driven by expectations of germination conditions to achieve optimal plant populations, as well as climate conditions (specifically, lack of precipitation) that will maximize the yield of the given plant population (Fig. 3).

Crop insurance

More than 85% of respondents reported making crop insurance purchase decisions in the winter and spring, in conjunction with the March 15 deadline for both corn and soybeans (Fig. 4). Decisions are made as to the type of plans to purchase, the level of coverage, and level of price protection, and are made in the context of reducing price risk and yield risk from such factors as drought, heat, hail, excess moisture, frost, etc.

Use of cover crops

Although only about 20% of producers overall reported using cover crops, those who did use them reported that their primary decision-making months were linked with the timing of planting of cover crops (Fig. 4). Planting spring cover crops was associated with spring decision making (highest in northern and central parts of the Corn Belt). And for those planting in the fall or the winter, fall was the most important decision-making time (highest in eastern and western parts of the Corn Belt).

Propane purchase

Approximately 60% of respondents reported making decisions about propane purchases throughout the summer and fall, towards the end of the crop management year, in conjunction with the need for drying corn outside of the field to achieve optimal moisture content for storage and milling quality (Fig. 4).

Use and influence of climate-based information

Most respondents (81%) reported using some type of weather-related decision-support resource. Sixty-two percent said they had used a growing degree day tool, measuring heat accumulation units that predict the growth and development of crops. Fifty-three percent had used a drought monitor or outlook such as the U.S. Drought Monitor, which depicts current drought conditions across the U.S., or monthly or seasonal drought outlooks provided by the NOAA Climate Prediction Center. Forty-five percent had used a crop disease forecast and 49% had used an insect forecast. Only 18% had used satellite

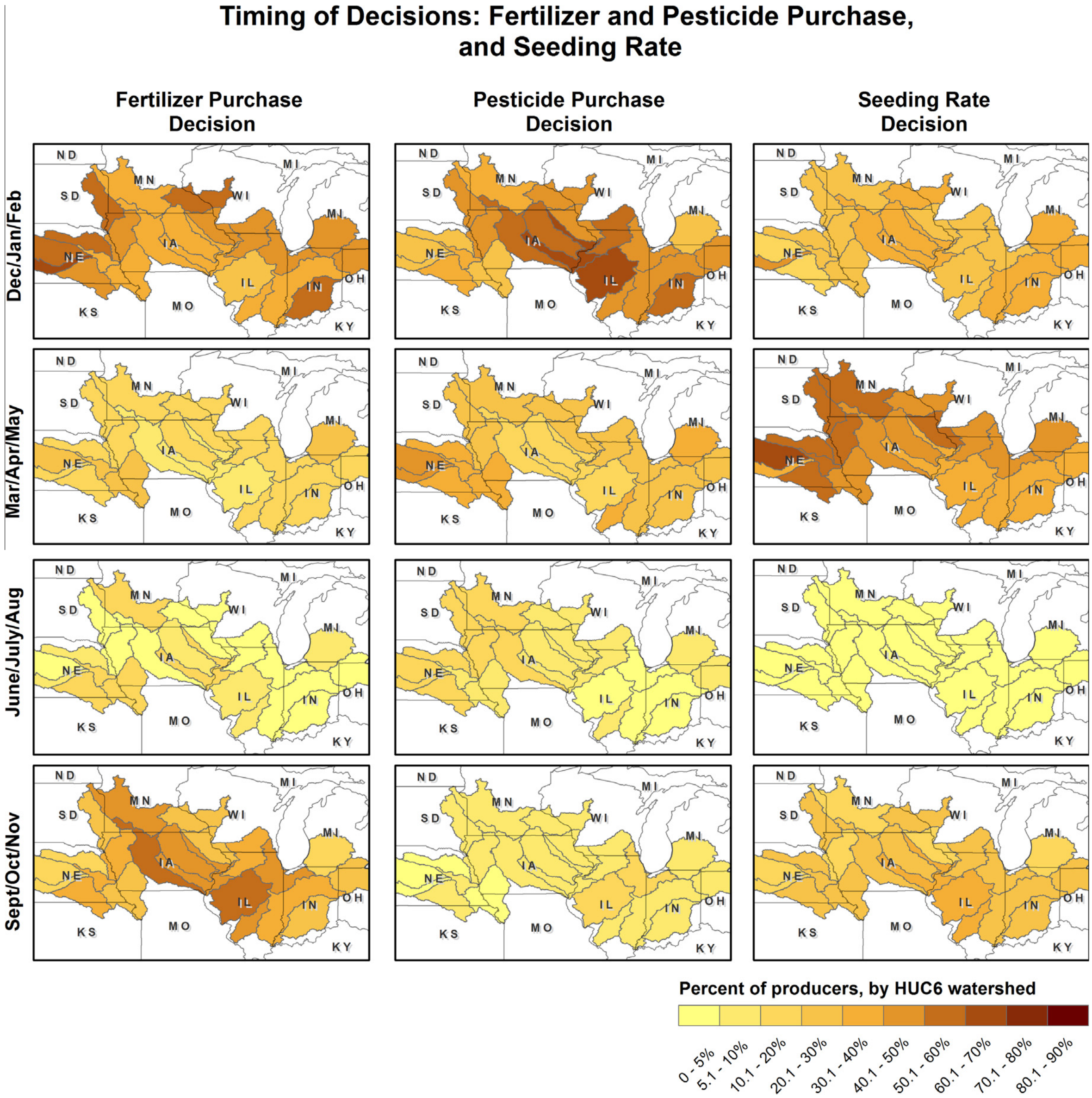

Fig. 3. Percent of producers, by watershed, making fertilizer purchase, pesticide purchase, and seeding rate decisions in each season.

Table 1
Percent of respondents making fertilizer purchase decisions in each season by fertilizer type (anhydrous or dry) and application time period (spring or fall).

	Winter purchase decision (%)	Spring purchase decision (%)	Summer purchase decision (%)	Fall purchase decision (%)
Apply anhydrous spring (n = 1665)	44	17	6	34
Apply anhydrous fall (n = 1272)	27	4	13	56
Apply dry fertilizer spring (n = 2650)	5	22	5	22
Apply dry fertilizer fall (n = 2331)	36	6	8	49

data or indices of water or soil nitrogen status, and only 14% had used a forage dry-down tool. There was some spatial variability in the use of some weather decision-support resources; for example, use of a drought monitor/outlook was higher in the western, more arid part of the Corn Belt than in the eastern part of the Corn Belt (Fig. 5).

Respondents across the Corn Belt reported that historical climate information and longer-term climate outlooks had a “low” level of influence on them, while at the same time they reported being “moderately” to “strongly” influenced by

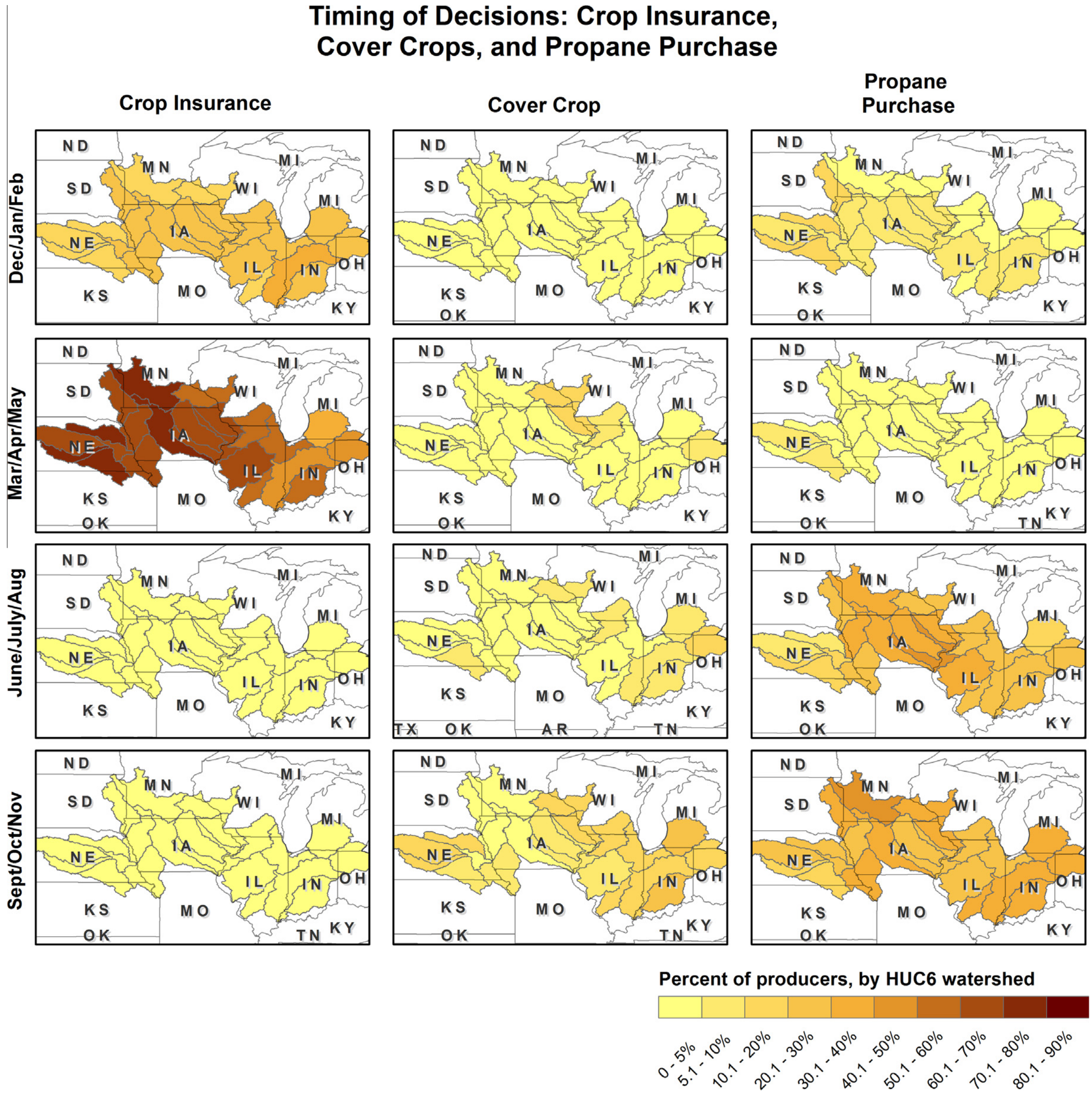

Fig. 4. Percent of producers, by watershed, making crop insurance, cover crop, and propane purchase decisions in each season.

current weather and 1–7 day forecasts (Table 2). With regard to longer-term outlooks, one Indiana producer (2012) said, "long term, frankly I don't pay much attention to it because it's... about as right as I am."

Focus group participants provided mixed views on the usefulness of climate forecasts to inform specific risk management decisions. With regard to field assignment and seeding decisions, one producer said, "February and March is when were deciding what to plant where. If I had soil temperature and moisture [forecasts for the spring], I could make [decisions] in advance, instead of in the field....If had better tools for those things I could plan better" (Nebraska producer, 2013). However, others disagreed, saying "most of the hybrids we have, I don't think we'd change 'em much," (Indiana producer, 2012) and "You just don't plan on it... Some years, the earlier stuff is the better stuff and in some years the later stuff is the better stuff. Just, you live on average" (Indiana producer, 2012).

Many focus group participants thought that climate information could be useful for fertilizer-related decisions. One participant said "...if you told me that we probably weren't going to recharge the soil [moisture profile], we'd start thinking about how we split-apply as much as we possibly can and trickle on the nutrients and everything else" (Indiana producer, 2012). Climate forecasts for the upcoming winter months may help producers make decisions about fall application of nitrogen, according to one focus group participant, who said, "if you're half-way reasonable in your forecast and it's looking like it's going to be a warm, wet winter, well then maybe you just ... wait until spring [to apply nitrogen])" (Indiana producer,

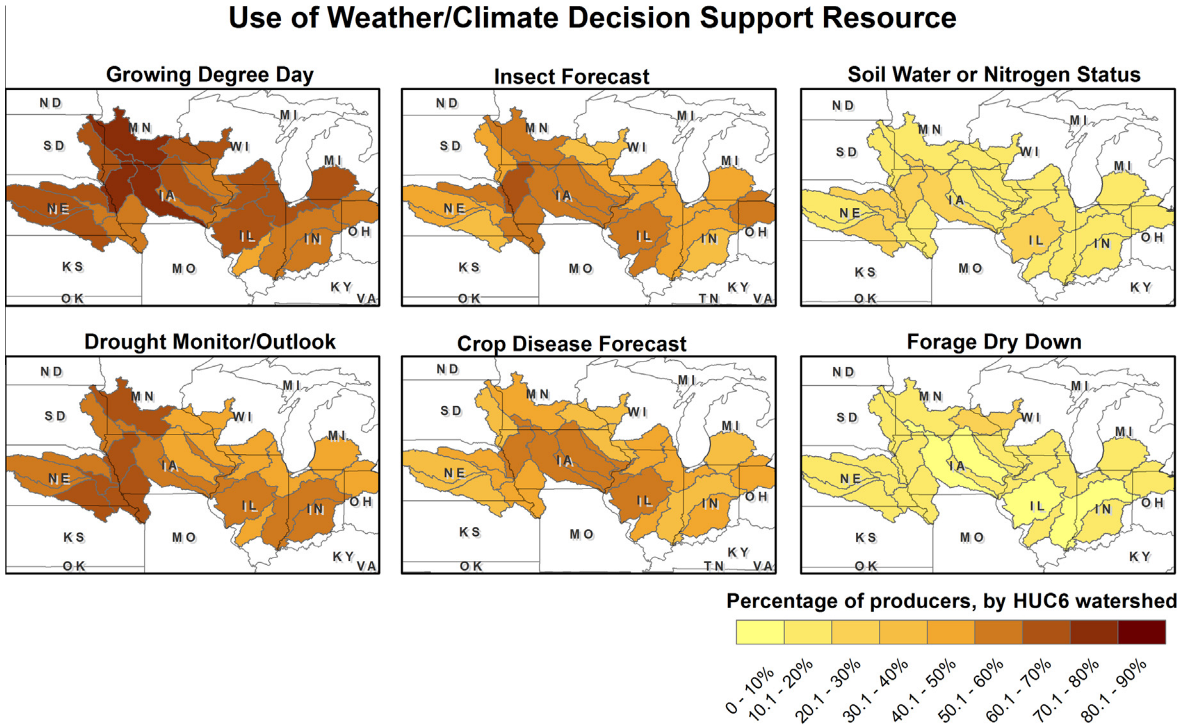

Fig. 5. Percent of producers by watershed who report use of decision-support resources.

Table 2
Mean and standard deviation of influence (1 = no influence, 2 = low influence, 3 = moderate influence, 4 = strong influence) on farm decisions. Groups (A, B, C, D, E) differ from one another at a 95% confidence level.

Type of weather/climate information (n)	Mean (St. Dev.)
Current weather (4523)[A]	3.33 (0.81)
1–7 day forecast (4546)[A]	3.37 (0.77)
8–14 day outlook (4532)[B]	2.92 (0.84)
Monthly/seasonal outlook (4521)[C]	2.32 (0.83)
Historical (4529)[D]	2.11 (0.90)
Past 12 months (4502)[D]	2.06 (0.81)
Annual/longer term outlook (4513)[E]	1.98 (0.83)

2012). However, not all participants thought climate information would influence their input decisions. Some prefer a "KISS: Keep It Simple, Stupid" method that would not change from year to year (Indiana producer, 2013).

Relevant to the use of historical climate information, focus group participants did express interest in comparing current conditions to past years, particularly with respect to drought, although they were not sure how to use that information. One Nebraska focus group participant (2013) said, "We're always looking backwards. How could we use the backwards data to look forward?"

Discussion: gaps/opportunities in climate information use and availability

According to Hollinger (1991), the role of climate information in tactical and strategic decision making may be to inform a general game plan of crop type and variety as well as fertilizer and pesticide programs, and to frame the "what if" questions that agricultural decision makers ask themselves to develop response options.

In the fall, many producers across the U.S. Corn Belt are making decisions about fall tillage and are beginning to think about crop and field assignments and seed purchases. Whether the decision to use fall tillage successfully optimizes planting conditions for the next crop, as well as whether the decision leads to on-farm and off-farm problems associated with soil erosion, depends upon weather conditions of the upcoming fall, winter, and spring. Similarly, whether decisions about crop choice, seed purchase, and field assignment lead to optimized yields or not depends upon factors such as spring soil temperatures and moisture, the dates of the last freeze of spring and the first freeze of fall, growing degree day accumulation, temperatures at pollination, and precipitation amounts and timing throughout the upcoming winter, spring, summer, and fall.

The success of winter decisions about fertilizer and pesticide purchases are likewise affected by climate factors such as spring and summer precipitation amount and timing and soil temperatures. For example, field wetness dictates opportunities for field work, heavy rains increase the risk of fertilizer runoff and leaching, warm soils increase loss of anhydrous ammonia to evaporation, plant growth affects timing of nutrient uptake, drought prevents crops from using applied fertilizer, and moisture and temperatures affect the need for, and effectiveness of, specific pesticides.

Spring decisions about seeding rate may be modified by growers' expectations of spring soil conditions as well as precipitation over the coming growing season, along with the hybrid selected and yield goal. Likewise, while decisions about crop insurance purchases have much to do with lending requirements and complex global markets and subsidy programs, information indicating the probability of climate risks over the upcoming cropping season may be useful to producers making decisions about the level of coverage purchased (Cabrera et al. 2006).

Spring and fall decisions about cover crops may be classified as operational (e.g., deciding how to get crops planted in a timely manner) or as tactical and strategic (e.g., choosing cover crops likely to survive an upcoming winter, deciding in which fields cover crops will have the most benefit, or deciding whether to invest in the equipment necessary to use cover crops). Correspondingly, the success of these decisions may depend not only upon short-term weather conditions affecting whether producers can into get the field (or have to call in an airplane to aerially seed crops), but also seasonal climate conditions affecting cover crop survival or risk of soil erosion, and long term climate trends, set in a historical context, which might indicate the future profitability of cover crop use.

And finally, summer and fall propane purchases are made within a context of locking in the best price and whether or not crops will be able to dry sufficiently in the field. Purchases made earlier in the season may result in better prices, which may make information available in the summer about fall harvest conditions (precipitation and temperatures), along with historical climate information, valuable for these decisions.

"What if" thinking about these tactical and strategic questions would clearly benefit from additional climate information. Yet while respondents indicated use of many currently available climate based-decision support resources, survey and focus groups results found skepticism about the usability of the types of long term climate outlooks and historical climate information that would appear to best inform risk management decisions. Level of skill or accuracy clearly remains a concern, even though some researchers have found that for some purposes, such as the "what if" planning exercises described above, less accurate information available with a longer lead time may have more value than more accurate information available later (Easterling and Mjelde, 1987; Changnon et al., 1988).

The level of skill and certainty of weather and climate information depends heavily on forecast lead time, location, the variable being forecast, season, and even time of day (Barnston et al., 2010; Kalnay et al., 1998; Quan et al., 2012). In the Midwestern U.S., most forecasts have been found to be more reliable in the cold seasons than in warm seasons, and forecasts of temperature are in general more skillful than those of precipitation (Wilks, 2000). Thus some forecasts might be more useful in southern or eastern regions of Corn Belt, where there is potential for winter moisture infiltration, than in the northern Corn Belt regions, where winter moisture infiltration is negligible. This is a specific example of how the integration of decision calendars and climate information use may vary regionally.

Survey results and focus group discussions show that historical climate information is underutilized in agricultural risk management. This is an area of untapped potential that is little explored in the literature and often overlooked by decision makers. Historical weather data can provide a quantitative assessment of real climate risks, which can be made valuable with effort to interpret the information for agronomic tactical and strategic decision making. One example of a product that integrates year-to-date weather data with historical climate information for agricultural decision making is the U2U Corn GDD_{DST}. This tool was launched in late 2013 based, in part, on findings from the aforementioned producer survey and with input from focus group participants. With the Corn GDD tool producers can track accumulated modified growing degree days (GDD) and compare current conditions against historical values. A forecast of GDD accumulations from current day through the end of the season based on historical patterns of GDD accumulations is also provided. Producers provide simple inputs including location, planting date, and corn maturity requirements to get customized outputs such as estimated dates of reaching corn growth stages and potential for damaging frost at planting and harvest. This information provides guidance for determining optimal planting dates, variety selections, marketing strategies, and propane purchases (U2U, 2014a).

Supplementing climate forecasts with historical data may be another way to bring usable climate information to agricultural producers (Changnon, 2004). For instance, in recent decades considerable attention has been given to particular conditions in the sea surface temperatures in the equatorial Pacific Ocean basin known as El Niño-Southern Oscillation (ENSO). These conditions are divided into El Niño (warm water phase), La Niña (cold water phase) and ENSO-neutral phase. These conditions have been linked to regional and global impacts of crop production (e.g., Iizumi et al., 2014). NOAA's Climate Prediction Center provides regular forecast of ENSO conditions for 9 months ahead. As a result, pairing an ENSO forecast with information about how ENSO has historically influenced local temperatures, precipitation patterns, and crop yields can help producers with a variety of decisions depending on the time of year. This approach has been successfully applied to the southeastern U.S. with the AgroClimate system (Breuer et al., 2008). Impacts of ENSO on Midwestern corn yields have been found (Carlson et al., 1996) and a similar approach to AgroClimate is being developed (U2U, 2014b).

Extension climatologists and other climate scientists who frequently give public talks in rural areas of the Midwest field a lot of questions from agricultural producers about recent trends toward heavy rainfall events, especially in spring and early summer. This change in precipitation is part of a well-documented trend and consistent with trends projected for mid-century climates simulated by climate model ensembles (Kunkel et al., 2013). Producers are expressing a belief that there will be fewer days suitable for field work by increasingly installing subsurface drainage tile and purchasing equipment that enables faster spring planting. This widely recognized trend in historical data may be an opportunity to better demonstrate use of climate projections for agricultural decision making.

Conclusion

Agricultural producers manage many different types of risk, including production risk, market risk, institutional risk (changing policies), human/personal risk, and financial risk (capital and financing) (Harwood et al., 1999). Almost every day begets a decision that will shape the producer's risk over the next few days or weeks (''Should I spray now or next week?''), months or seasons (''Which variety should I plant?''), and the coming years (''Should I invest in an irrigation system?''). While producers claim to currently use a variety of weather-related decision-support resources, lack of trust in most climate information may limit the degree to which the information is actually incorporated into decisions. The timing of many tactical decisions may also be limiting potential usability of climate information.

We found the decision calendar approach to be effective in describing seasonal decision making and ''entry points'' for climate information into those decisions. There was sufficient variability in the timing of decision making to justify the development of localized decision calendars. Such localized decision calendars might be used to guide the development of tools or educational programs targeted at decisions that vary geographically.

We found it difficult to measure decision-making dates for strategic decisions because they are not necessarily of a ''cyclical, recurrent'' nature, but climate information is certainly relevant for informing choices on these longer time horizons. While decisions about use of cover crops may be thought of as strategic, it appeared that survey respondents placed the decision on the calendar as tactical, in close reference to the time they actually plant cover crops. Future research may investigate other options for measuring the timing of strategic decisions, or propose something other than an annual calendar to describe strategic decision making and associated climate considerations.

These findings support further investment in the use of historical climate information to quantify potential climate risks for agricultural decision makers. Additional development of user-friendly tools may answer our focus group participant's question about how to use information from the past to look forward.

Finally, while climate information developers need to actively listen to and understand stakeholders' needs, further outreach is also needed to help agricultural decision makers understand both the limitations and potential uses of climate forecasts. Additionally, to improve the uptake of climate information in the agricultural community, climate scientists may need to bear the burden of demonstrating more explicitly the utility of climate forecasts and historical climate information. A path forward in this regard is offered by the example of historical information on spring-summer precipitation trends in the upper Midwest: if recent trends of climate variables of significance to decision makers are consistent with trends projected by climate models there is opportunity to open dialog on more extensive use of climate forecasts for decision tools.

Acknowledgements

This research is part of ''Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers,'' and is supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-68002-30220 from the USDA National Institute of Food and Agriculture. Project website: http://www.AgClimate4U.org. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. The views expressed herein are those of the authors and do not necessarily reflect those of the associated institutions. The authors would like to thank Chad Hart, Brian Fuchs, and Richard Little for providing insight on agricultural decision making. We also thank the anonymous reviewers of this paper for providing valuable insights and questions, and Kelly Helm Smith and Deborah Wood of the National Drought Mitigation Center for editing assistance.

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